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Photograph by A. C. Best

MR J. K. BANNON, I.S.O.

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RETIREMENT OF MR J. K. BANNON, I.S.O.

On the retirement of Mr J. K. Bannon as Director of Services on 26 April 1976 the Meteorological Office lost another of its major figures of the post-war era. In an outstanding career spanning 38 years John Bannon filled a wide variety of posts in both the Services and Research Directorates, to all of which he brought a high degree of dedication, professional ability, excellent judgment, and sound common sense, qualities that have been of immense service to the Office in a period of rapid change and modernization.

Educated at the Royal School, Armagh, he entered Emmanuel College, Cambridge in 1935 and graduated as a Wrangler in the Mathematical Tripos in 1938. Soon afterwards he joined the Meteorological Office as a Technical Officer, and, after a succession of forecasting posts at Mildenhall, Sullom Voe, Pembroke Dock, and H.Q. 93 Group, RAF, he was commissioned as a Flight Lieutenant, RAFVR, in 1943 and posted to H.Q. Bomber Command. In 1944 he was promoted Squadron Leader and served with the 2nd Tactical Air Force in Europe until the end of the war. Upon demobilization in 1946 he returned to the Meteorological Office as a Senior Scientific Officer in the General Research and Observatories Branch under A. C. Best, where he published a number of important and still-quoted papers on the estimation of large-scale vertical currents from rates of rainfall, on the humidity of the upper troposphere and lower stratosphere based on the pioneering frost-point hygrometer measurements of the Meteorological Research Flight, and on the incidence of severe turbulence at high altitudes. In 1952 he moved to the Upper Air Climatology Branch where he investigated the structure of the Middle East jet stream, and wrote important papers on the temperature structure of the troposphere and lower stratosphere (with A. Gilchrist), on stratospheric temperatures over the Antarctic, and on the flux of water vapour due to the mean winds over the northern hemisphere (with A. G. Matthewman and R. Murray). Well-deserved promotion to Assistant Director in charge of the Special Investigations Branch came in 1960.

Selection for the Imperial Defence College in 1963 pointed to further advancement and, after successive spells as Assistant Director for Aviation Services, for Public Services and for Observational Requirements and Practices, promotion to Deputy Director (Observational Services) followed in 1971. His services had been given public recognition in 1969, when he was appointed a Companion of the Imperial Service Order. In 1973 he succeeded Mr P. J. Meade as Director of Services with the rank of Under Secretary.

In this onerous post, by quiet and firm leadership and a realistic sense of priorities, he was able to meet unprecedented demands for both old and new services, partly by the smooth introduction of automatic methods but, above all, by securing the willing co-operation of his staff. His open-mindedness and ability to see the Services and Research Directorates as complementary rather than as rival parts of the same organization have brought them closer together than ever before.

His wise and courteous counsel and quiet good humour will be greatly missed, especially by those of us who have been privileged to work closely with him over the years.

I am sure that all John Bannon's friends and colleagues will wish to join me in wishing him, and Mrs Bannon, a long, active and happy retirement.

B. J. MASON

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AN ANALYSIS OF PRESSURE JUMPS AT LUQA, MALTA IN THE YEARS 1968–72

By J. D. PERRY

Summary

Analysis of pressure jumps at Malta for a five-year period shows the maximum frequency to be associated with synoptic situations where an easterly airstream at the surface is separated from a potentially unstable layer in the middle troposphere by a marked inversion. These conditions are often accompanied by anomalous surface winds which may satisfy squall criteria. Severe low-level turbulence reported in these circumstances is discussed and there is an Appendix indicating the factors favourable to such developments, which present a particular hazard in that they may occur in clear air.

Introduction

Several reports of pressure jumps at Luqa have been published, notably by Lamb (1954) and Kirk (1961, 1963a–d), showing rapid changes of pressure of from one to two millibars which were associated with oscillatory surface-wind effects and thermogram discontinuities. A more recent occasion of pressure jumps which occurred at a time when severe low-level turbulence was being reported by aircraft which were landing at Luqa prompted this investigation of the phenomena, and an analysis of data for the five-year period from January 1968 to December 1972 showed that pressure jumps of two millibars or more were not uncommon. The conditions associated with these jumps were similar to those given by Hardy (1971) as a prerequisite for low-level turbulence in Cyprus.

Definition of pressure jumps and of their frequency

If a pressure jump is defined for the purpose of this investigation as a change in pressure of at least two millibars in a period not exceeding one hour, then during the five-year period from January 1968 to December 1972, 252 pressure jumps were recorded by the two barographs at Luqa, Malta. The jumps, both positive and negative, were equal to or in excess of 3 mb on 75 occasions, 4 mb on 20 occasions, and 5 mb on 4 occasions. This definition embraces

both sudden changes of pressure and steady but rapid changes of pressure which show in the routine observations as a pressure tendency of at least 6·0 mb in three hours. The sudden changes which comprise the majority of the data examined usually become obscured in the tendencies calculated for routine observations, while large but steady changes of pressure are much less frequent in the central Mediterranean area than they are in higher latitudes, and very few of the 252 pressure jumps fall in this category.

The annual frequency of pressure jumps is given in Table I below, and it is noteworthy that 1970 had remarkably fewer pressure jumps than the other years.

TABLE I—ANNUAL FREQUENCY OF PRESSURE JUMPS, 1968–72

	⩾ 2 mb	⩾ 3 mb	⩾ 4 mb	⩾ 5 mb
1968	57	18	4	0
1969	52	15	6	0
1970	29	7	0	0
1971	57	19	6	1
1972	57	16	4	3
Total	252	75	20	4

Frequently a sudden increase of pressure was followed by a fall, or vice versa. On some occasions the reversal of jump was delayed by several hours, while isolated jumps of pressure without recovery were not uncommon. Although the chance of a pressure jump occurring in any one hour is, on the basis of this study, less than 1 per cent, it is evident from examination of the barograph traces that the likelihood of a pressure jump increases significantly during periods when the trace is unsteady. Figure 1 shows the barograms for the period 24 July–6 August 1972 and it will be seen that the normal diurnal variation of pressure is disturbed on 30 and 31 July and again on 2 and 3 August. During these periods the traces became irregular with minor fluctuations of pressure before a series of significant pressure jumps. The jumps on 31 July occurred in rapid succession whereas the first two jumps on 2 and 3 August were separated by about six hours. The final jump on 3 August was a rapid fall immediately followed by a rise. If a sequence is defined as all those pressure jumps separated by less than three hours between jumps then the annual frequency decreases appreciably as shown in Table II.

TABLE II—ANNUAL FREQUENCY OF SEQUENCES OF JUMPS, 1968–72

	⩾ 2 mb	⩾ 3 mb	⩾ 4 mb	⩾ 5 mb
1968	33	11	2	0
1969	31	11	4	0
1970	18	7	0	0
1971	29	8	4	1
1972	35	10	4	3
Total	146	47	14	4

Frequency by month and time of day (GMT)

Table III shows the diurnal and monthly frequency distribution of pressure jumps for the five-year period from 1968 to 1972. It is evident from the table that pressure jumps are most likely during the period April–September and between the hours 2100 GMT and 0600 GMT. Examination of the barograms and relevant surface observations showed that this distribution was mainly attributable to periods of easterly surface winds at Luqa, Malta.

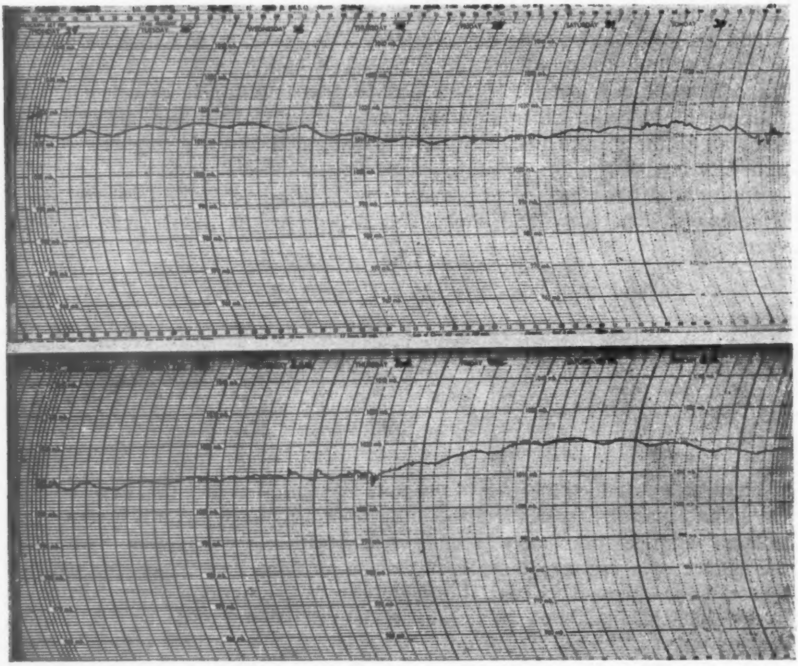

FIGURE 1—BAROGRAPH RECORD AT LUQA, MALTA, 24 JULY–6 AUGUST 1972

TABLE III—FREQUENCY OF PRESSURE JUMPS BY MONTH AND TIME OF DAY, 1968–72

Time (GMT)	J	F	M	A	M	J	J	A	S	O	N	D	Year
0000–0259	1	0	3	3	6	6	4	9	1	1	1	0	35
0300–0559	0	0	7	1	7	10	4	2	12	0	0	0	43
0600–0859	0	0	2	2	6	0	7	3	8	0	1	0	29
0900–1159	1	3	0	3	6	3	1	2	4	0	1	2	26
1200–1459	0	2	3	8	5	2	0	5	3	1	1	1	31
1500–1759	0	0	1	5	3	5	1	1	3	0	2	0	21
1800–2059	0	0	1	3	1	6	2	3	6	2	1	0	25
2100–2359	1	0	2	5	3	8	3	7	6	2	2	3	42
Total	3	5	19	30	37	40	22	32	43	6	9	6	252

Association with prevailing wind direction and discussion of anomalous wind effects

To obtain a true representation of the surface wind direction prevailing at the time of pressure jumps, and to remove any anomalous effects, the mean wind directions for the three-hour periods preceding and following the hour in which the pressure jump occurred were extracted. Figure 2(a) shows the number of observations of pressure jumps expressed as a percentage of the total number of pressure jumps for 30° ranges of wind direction.

The majority of pressure jumps occurred during periods of easterly winds; however, it must not be assumed that this direction is most frequent at Luqa, Malta. As shown by Figure 2(b), westerly to north-westerly winds are most in evidence and a secondary maximum in the frequency of pressure jumps occurs with winds in this sector. The distribution for individual months is similar. If the percentage frequency of pressure jumps in 30° ranges (see Figure 2(a)) is expressed as a percentage of the percentage frequency of winds occurring in the appropriate sector, a normalized distribution of pressure jumps associated with various wind directions is obtained. Figure 2(c) shows that the secondary maximum for north-westerly winds is absorbed in this distribution and that pressure jumps occur with predominantly easterly winds.

A pressure jump is defined by the Meteorological Glossary (London, Meteorological Office, 1972) as a rise of pressure often accompanied by the arrival of a line-squall. The wind criteria for a squall, however, were only satisfied on 10 occasions out of 252, but on many occasions near-squall conditions prevailed, sudden gusts or lulls often occurring with winds coming from a reciprocal direction, so that conditions could be described as 'effective squall' on a considerable number of occasions; the change of direction to a westerly rather than an easterly direction was attributed to a break-through of the wind regime at medium levels. Study of the 20 examples of pressure jumps of 4 mb or more to be discussed later showed that the wind normally veered with height from an easterly flow at the surface to a westerly flow at 700 mb.

Although rapid and marked changes in wind direction and speed frequently occurred at the time of a pressure jump, in the majority of cases the mean wind direction, that is to say over ± 3 hours, showed little change other than a slight backing as illustrated in Figure 2(c). The speed of the wind did not appear to be critical, with the mean wind speed for the three-hour period preceding the pressure jump varying from less than five knots to near-gale force, while the mean wind speed showed little change in the majority of cases afterwards.

Weather and cloud associated with pressure jumps

Usually the pressure jump occurs in cloudy conditions with unstable medium cloud or cumulonimbus present in the vicinity, while precipitation may vary from a trace to heavy rain associated with a thunderstorm; a squall may occur. On the other hand pressure jumps have occurred with clear skies or with no precipitation when cloud was present, and with little or no change of surface wind. Table IV shows the distribution of cloud and precipitation on occasions of pressure jumps during the five-year period studied. Since conditions vary considerably for individual pressure jumps it is of interest to look at the rather unusual weather associated with the examples shown on the barograms depicted in Figure 1.

Fine weather with light winds and little or no cloud continued from 24 to 27 July 1972, with the barogram showing the normal diurnal oscillations for a Mediterranean latitude. On 28, 29 and 30 July the normal diurnal pattern was interrupted at times and the trace became unsteady with several short-period fluctuations while periods of easterly winds occurred. These winds became fully established during the latter part of 30 July as a thundery depression moved north-eastwards across Tunisia into the Gulf of Gabes. An

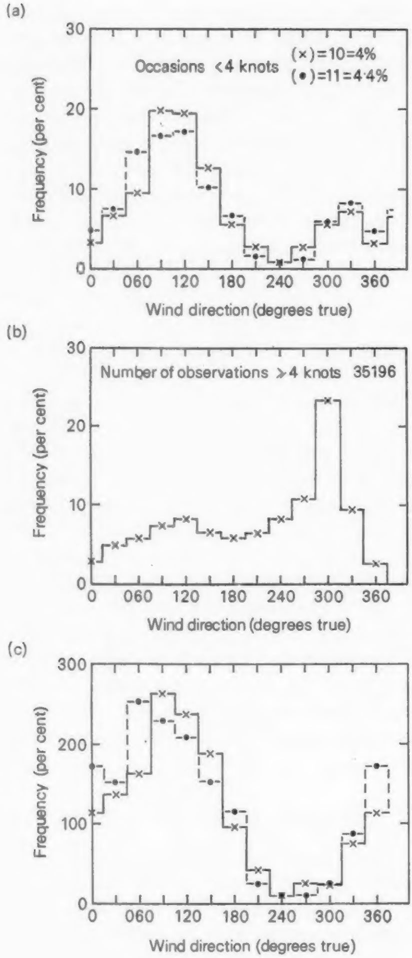

FIGURE 2—SURFACE WIND DIRECTIONS ASSOCIATED WITH PRESSURE JUMPS AND PERCENTAGE FREQUENCY OF WIND DIRECTIONS FOR LUQA, 1968–72

(a) Frequency of pressure jumps (as a percentage of total (252)) plotted against associated wind direction in ranges of 30°.
(b) Percentage frequency of wind direction in 30° ranges for wind speeds ⩾ 4 knots (all available hours 1968–72).
(c) Frequency of pressure jumps as percentage of frequency of associated wind direction plotted against direction in ranges of 30°.
–×– mean wind direction for three hours preceding a pressure jump
– • – mean wind direction for three hours following a pressure jump

associated trough of low pressure extended northwards to Italy and this moved eastwards across the Maltese islands on the evening of 31 July.

Unstable medium cloud increased to 7 oktas between 0300 and 0400 GMT on 31 July, giving intermittent rain for several hours, and the barograph oscillated markedly, with the pressure rising by over 5 mb in a few minutes at about 0730 GMT. Soon afterwards a roll cloud was observed below the main cloud layer and considerable locally raised dust reduced the visibility to about 3 km on the airfield. A report of property damaged by a whirlwind was received later in the day.

The wind (see Figure 3), which had been mainly south-easterly initially, increased rapidly at times to 25 kn with gusts to 31 kn during the period from 0500 to 0730 GMT, and veered to westerly at 0740 GMT. Immediately afterwards the wind returned to the south-east, with a gust to 41 kn during the shift, and within 10 minutes had decreased to about 10 kn. Further marked variations in the wind direction followed, with the speed varying between calm and 20 kn before the wind settled in the easterly sector again and the upper cloud started to disperse. This direction persisted until 2000 GMT when a north-westerly wind developed and the normal diurnal pressure pattern was re-established.

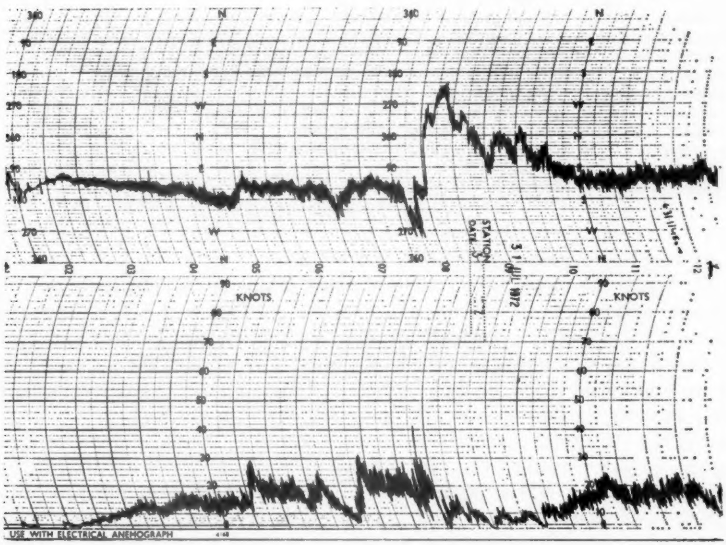

FIGURE 3—ANEMOGRAPH RECORD FOR LUQA, MALTA ON 31 JULY 1972

On 1 August the wind was light and variable, but the south-easterly set in on 2 August and was associated with an unsteady barograph trace; this situation was to last until a veer to the north-west on 3 August at about 1400 GMT when once again the normal diurnal pressure oscillation was resumed.

Of the three large pressure jumps which occurred during the period of south-easterly winds on 2 and 3 August, the first was not associated with any marked change in wind. The second, which occurred some six hours later with light south-easterly winds, was associated with a north-westerly squall of 36 kn followed by light and variable winds and subsequently a return to a light south-easterly wind.

The last pressure jump at 1245 GMT on 3 August coincided with the passage of a surface trough, and winds, which had initially been southerly to south-easterly 10–15 kn, increased rapidly to 25 kn with the pressure jump; thereafter they veered west to north-west, where they persisted for the rest of the day at about 15 kn. The significant feature of this last pressure jump was a marked roll type of cloud and two aircraft reports of turbulence. In the first a British Airways (European Division) Trident reported severe clear-air turbulence between 2000 ft and 3000 ft (approximately 0·6 km and 0·9 km). The other aircraft, an Antonov 24, also reported severe turbulence on the approach to Luqa, Malta, and was forced to make a second approach.

TABLE IV—CLOUD AND PRECIPITATION ASSOCIATED WITH PRESSURE JUMPS, 1968–72

Number of pressure jumps for the five-year period	252
Occasions with total cloud amount $\geq$ 5 oktas	233
Occasions with total cloud amount $<$ 5 oktas	19
Precipitation in hour in which pressure jump was observed	113
Precipitation in hour in which pressure jump was observed and also in preceding or following three hours	183
Thunderstorms or lightning seen in hour in which pressure jump was observed and preceding or following three hours	63
No precipitation in hour in which pressure jump was observed or preceding or following three hours	69
Squall occurring in hour in which pressure jump was observed	10

Twenty cases of pressure jumps of 4 mb or more

Table V lists the 20 occasions when pressure jumps of 4 mb or more occurred and these appear on the barograms depicted in Figure 4. The identifying numbers 1 to 20 given in the table are used for reference in the text and on the diagrammatic representations of the barograms. The times of the pressure jumps have been deduced from the daily register of meteorological observations, the clock errors of the barograms not being known with certainty.

On all the barograms except one, number 3 and 4, the large pressure jumps occurred during periods when the normal diurnal variation of pressure was disturbed, the trace was irregular, and often other significant pressure jumps followed in sequence. On 4–5 November 1968, however, the pressure jumps occurred during a thunderstorm associated with the passage of a marked upper trough after a period when the barometer had been normal in character, showing a minimum at 1500 GMT and a maximum at 2100 GMT. The rest of the jumps were not of this nature and occurred with surface winds having an easterly component.

Examination of the radiosonde ascent for Qrendi, Malta, showed that whereas the atmosphere on 4–5 November 1968 was unstable from near the surface to over 300 mb, the appropriate ascents for the other pressure jumps showed a marked similarity of type, having a potentially unstable layer between 800

TABLE V—PRESSURE JUMPS OF 4 mb OR MORE OBSERVED DURING THE FIVE-YEAR PERIOD 1968–72

Number	Time GMT	Date	Mean surface wind in degrees true and knots before (3 hours)	during hour	after (3 hours)	Remarks (times in GMT)
1	2149	11/6/68	080/09	040/08	010/14*	2230 effective squall
2	2248	11/6/68	060/08	310/20	050/09	250/20 gust 33 after lull
3	2247	4/11/68	220/13	220/21	300/15	0030 veer from SW to NW
4	0031	5/11/68	220/16	310/21	290/11	mean speed 26 kn gusts 38
5	1608	5/5/69	130/24	150/20	170/15	No significant change in wind
6	1651	5/5/69	130/24	150/20	170/15	1650 110/25 gust 34
7	1815	5/5/69	140/20	190/16	170/07	1805 effective squall 230/24 gust 32
8	1100	24/6/69	140/13	110/17	110/16	1110 gust 24 kn, 1215 gust 29 kn
9	2059	3/7/69	110/10	110/10	020/03*	2100–2145 300/05 gust 16
10	2245	24/8/69	190/10	200/13	150/14	2230 160/15 gust 19
11	0330	14/3/71	110/19	120/16	120/24	0330 sudden lull 200/05 or less
12	0415	14/3/71	120/18	120/22	130/25	No significant change in wind
13	0945	9/5/71	090/15	110/18	090/14	0945 no significant change in wind, 1015 calm
14	1145	9/5/71	100/13	080/14	100/18	1030–1200 slow increase to 100/20 gust 29
15	0215	6/7/71	120/13	310/06	050/07	0210 calm, followed by sharp increase to 300/12 gust 16
16	0726	6/7/71	080/10	120/16	130/15	0710 230/10
17	0730	31/7/72	160/16	150/20	130/11*	0735 effective squall 160/22 gust 29
18	2245	1/9/72	100/11	110/08	110/13	2215 variable, less than 5 kn
19	0335	6/9/72	110/09	110/13	050/11	0350 effective squall 310/19 gust 24
20	0515	15/9/72	130/12	250/12	090/11	0520 variable 5 kn 0525–0600 250/12 gust 18

Notes: Mean wind speeds and directions calculated independently as scalar quantities.
* Occasions when the wind direction fluctuated through more than 90°.

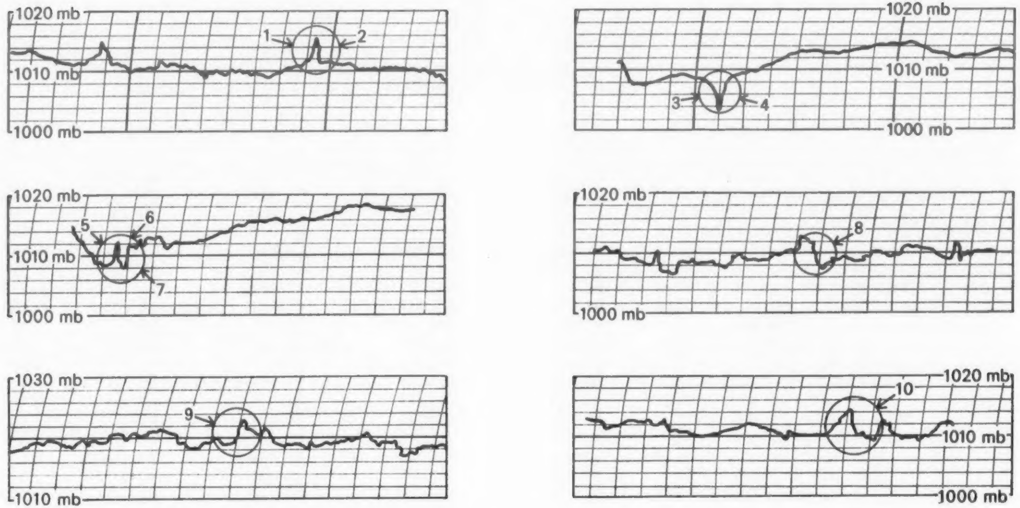

FIGURE 4—DIAGRAMMATIC REPRESENTATION OF EXAMPLES OF BAROGRAMS ON WHICH PRESSURE JUMPS OF 4 mb (OR MORE) WERE RECORDED

The barograms shown are for the following dates, with the number identifying the particular pressure jump, as listed in Table V, in brackets. 11 June 1968 (1 and 2); 4/5 November 1968 (3 and 4); 5 May 1969 (5, 6 and 7); 24 June 1969 (8); 3 July 1969 (9); 24 August 1969 (10).
Horizontal lines are at intervals of 2 mb; curved lines are at intervals of 3 hours.

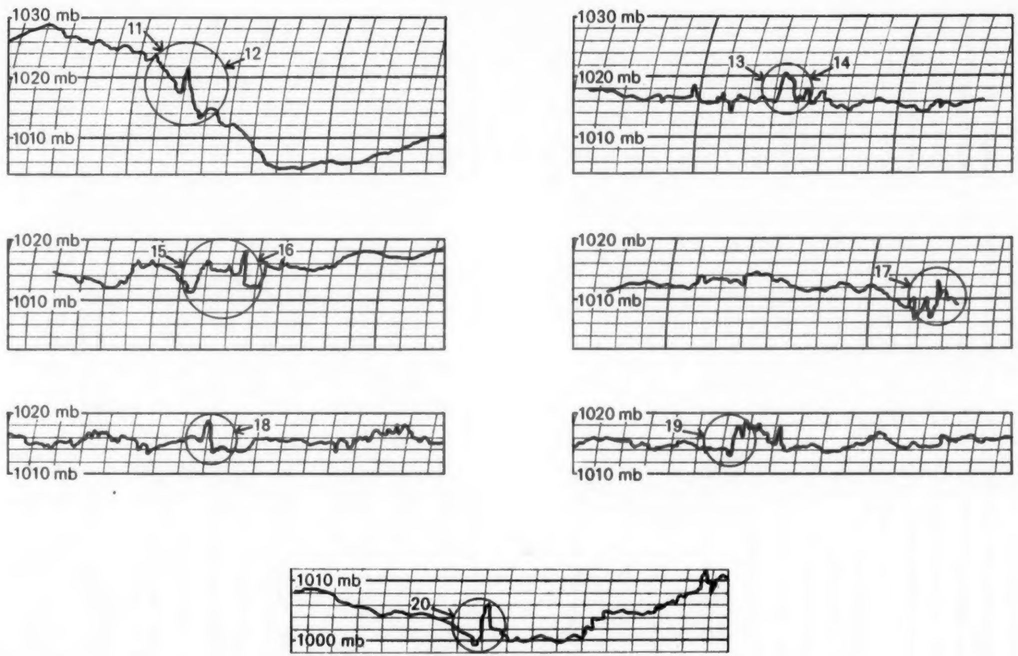

FIGURE 4—*continued*

The barograms shown are for the following dates, with the number identifying the particular pressure jump, as listed in Table V, in brackets. 14 March 1971 (11 and 12); 9 May 1971 (13 and 14); 6 July 1971 (15 and 16); 31 July 1972 (17); 1 September 1972 (18); 6 September 1972 (19); 15 September 1972 (20).

and 500 mb, approaching the dry adiabatic lapse rate (on some ascents this layer was dry, and on others considerable moisture was present) above an inversion at heights between 950 and 850 mb, and a cool layer near the surface. A typical ascent is shown in Figure 5. Examples of large and rapid changes of pressure in thunderstorms, often associated with upper troughs and/or squalls, of the type observed on 4–5 November 1968 are well documented. Excluding this event there remains the large proportion of pressure jumps recorded at Luqa which fall into a class of their own and occur in rather special conditions.

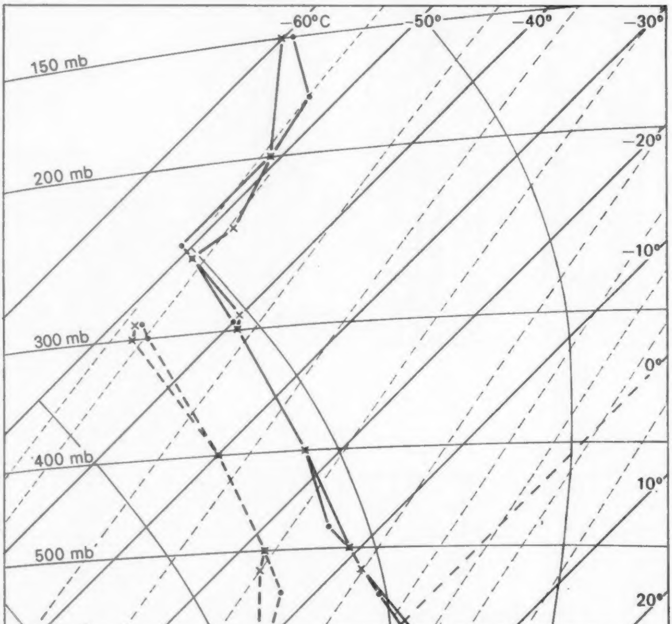

FIGURE 5—RADIOSONDE ASCENTS FOR QRENDI, MALTA, ON 31 JULY 1972

× —— × 00 GMT dry-bulb temperature
× – – × 00 GMT dew-point temperature
• —— • 12 GMT dry-bulb temperature
• – – • 12 GMT dew-point temperature

Of the 18 pressure jumps remaining all were found to be cloudy except one, 3 July 1969 (9), and precipitation fell on 11 occasions. Cloud and precipitation did occur within three hours of the jump on 3 July 1969, and, in all, 8 out of the 18 occasions had evidence of thunder within ± 3 hours. Perhaps the most important point about these observations is that although anomalous winds were recorded on several occasions (1 and 2, 7, 9, 11, 14, 15, 16, 17, 19 and 20) which approached squall criteria, there were other occasions (5, 6, 8, 10, 12 and 18) when no marked changes in wind occurred near the time of the pressure jump despite fluctuations of 4 mb or more. Comparison of the mean wind directions for three hours preceding and following the pressure jump confirmed the tendency for backing previously shown in Figure 2(c).

The winds, which had an easterly component at the surface, veered with height to become mainly westerly by 700 mb, this direction being backed some 30 to 40 degrees from the norm, as were the wind directions above 700 mb. The wind speed varied considerably from one jump to the next and there was no evidence of a critical wind speed at any particular height. Figure 6 shows the upper-wind distribution for the occasions of large pressure jumps; it is based on the mean surface wind in the three-hour period prior to the jump and the appropriate radar winds for Qrendi, Malta.

The vector mean winds were computed for these occasions and plotted as a hodograph, Figure 7, showing the mean wind shear typical of large pressure jumps. This shear pattern was found to be present on most occasions when pressure jumps occurred at Malta, and may therefore be used as a guide to indicate the likelihood of pressure jumps, and may also be usefully employed to explain anomalous surface-wind effects. It should be noted nevertheless that the hodograph shear pattern in itself is not sufficient to induce pressure jumps; nor should the latter if they occur be interpreted as indicative of anomalous winds at the surface, since there were several observations of pressure jumps in excess of 4 mb when the surface wind showed little or no significant change.

The highest gust recorded for this set of observations was 41 kn and this figure is in accord with the value found by using the regression equation of Fawbush and Miller (1954) which is strictly applicable to gusts in thunderstorms.

The cases discussed here were studied to see if any oscillatory motion was present for pressure, wind and temperature. Although on occasions pairs of jumps appeared to be similar in characteristic (see jump preceding number 17), the overall impression was that the pressure jumps were random in nature. Similarly, although on two occasions marked temperature changes were recorded, there being a rise of 9 deg in one hour and then a rapid fall of 6 deg on 24 June 1969 (8) and on 31 July 1972 (17) a rise of 2·5 deg followed by a fall of 1·5 deg during the effective squall, on all other occasions there were no significant changes nor were there any temperature oscillations. Slight wind oscillations occurred after pressure jumps 7, 9 and 18.

Turbulence

The sequence of events leading to the reports of severe low-level turbulence on 3 August 1972 have been discussed earlier. No other reports of turbulence which could have been associated with a pressure jump were received, possibly owing to the small chance of an aircraft movement coinciding with a pressure jump or to the fact that near-surface mechanical turbulence is frequently found

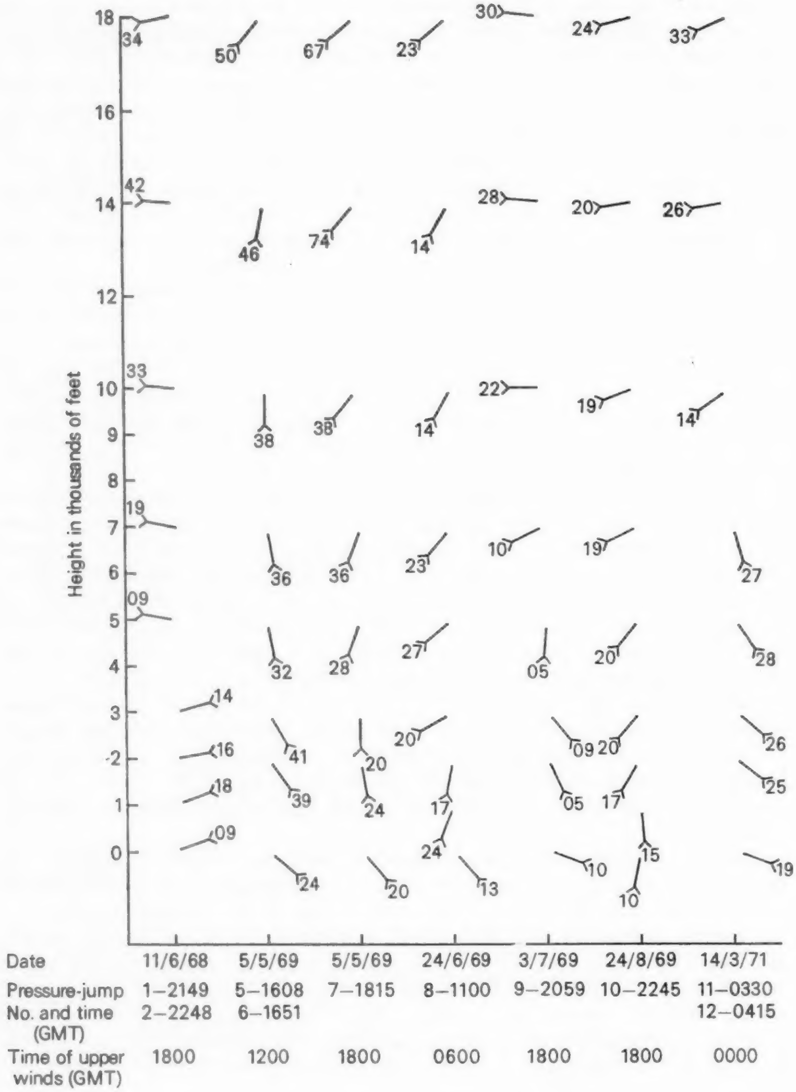

FIGURE 6—UPPER WIND DISTRIBUTION ASSOCIATED WITH PRESSURE JUMPS OF 4 mb OR MORE

Wind directions are in degrees true and wind speeds are expressed in knots (1 kn ≈ 0·5 m/s).

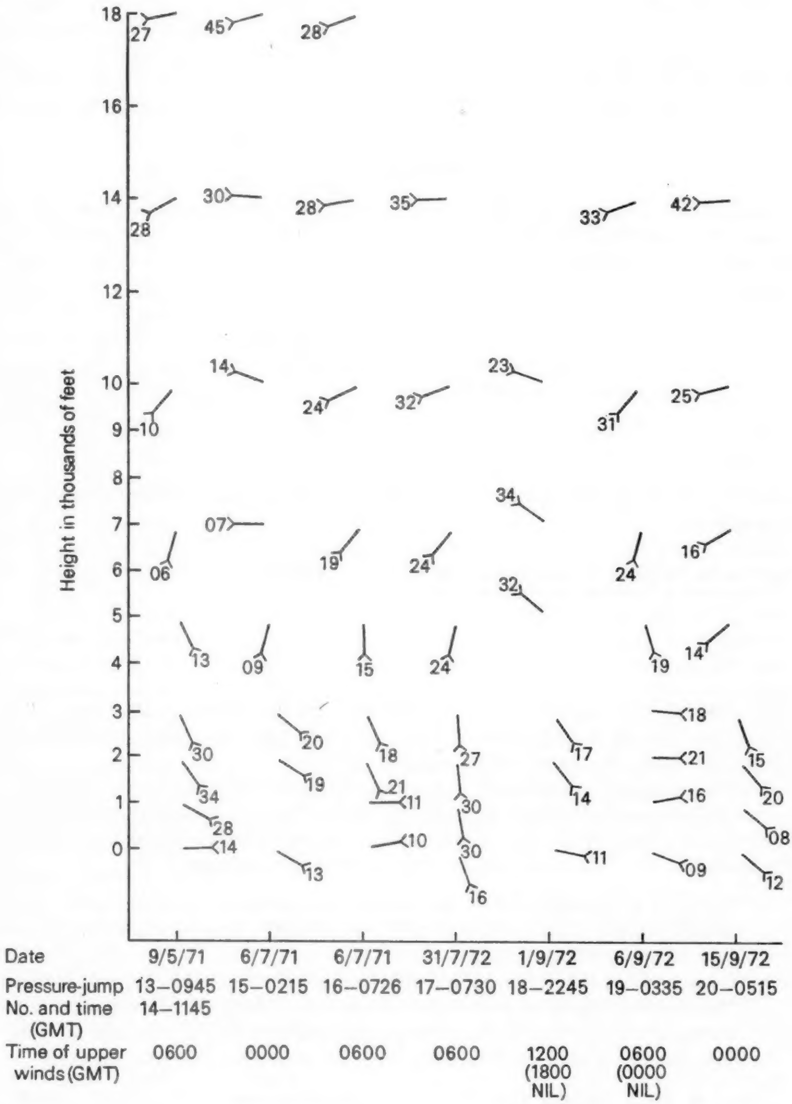

FIGURE 6—*continued*

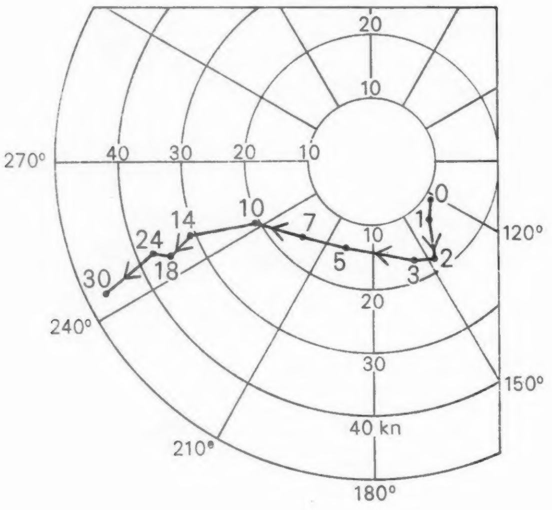

FIGURE 7—HODOGRAPH OF VECTOR MEAN WINDS ON OCCASIONS OF LARGE PRESSURE JUMPS

Heights are indicated in thousands of feet (1000 ft = 304·8 m).
The diagram is based on 14 observations.

with winds from a westerly direction at Luqa, Malta because of the proximity to the runway of a large hangar, and anything less than severe turbulence would probably not result in an aircraft report.

A certain similarity was noted between conditions obtaining during occasions of severe low-level turbulence reported by Hardy (1971) for the eastern Mediterranean and those which were found when pressure jumps occurred at Malta. In particular the following factors were remarkably similar.

1. Synoptic types common to the central and eastern Mediterranean.
2. Winds veering from a direction with an easterly component at the surface to a westerly above 700 mb.
3. Unsteady barograph trace (pressure jumps were also reported by Hardy).
4. On most occasions large amounts of medium or high cloud were observed.
5. Potentially unstable medium layers approaching the dry adiabatic lapse rate overlay a cool surface layer with an inversion at about 900 mb.

While it would appear that the conditions associated with pressure jumps at Luqa, Malta, are potentially likely to give clear-air turbulence, certain dissimilarities to those given by Hardy should be noted. They are:

1. Pressure jumps could occur at any time of the year—the turbulence reports of Hardy were restricted to the period from February to April.

2. A frontal system said to be usually associated with a surface low and strong upper jet was not necessary to produce conditions favourable to pressure jumps at Luqa, Malta, although a certain similarity of synoptic type is necessary to satisfy the conditions given above.

3. The minimum temperature recorded on the preceding night was not always above average—no significant correlation with the preceding night's minimum temperature having been found for the Luqa, Malta data.

Discussion

It has been demonstrated that pressure jumps at Luqa, Malta can occur at any time of day or year and with varying wind speeds and directions; however, they occur most frequently in rather special conditions. These require the wind to veer from an easterly component at the surface to a westerly by about 700 mb, while a potentially unstable medium layer (usually of desert origin) overlies air cooled by the sea track, resulting in a two-layer structure with an inversion at about 900 mb. The following synoptic types are therefore most likely to produce pressure jumps and the associated wind features:

A. Stationary or slow-moving upper trough–ridge patterns over the central Mediterranean, resulting in low pressure over Tunisia and a ridge of high pressure to the east of Malta.

B. Transient southerly or south-easterly airstreams ahead of desert lows or troughs moving north-eastwards from the west coast of Libya or south-eastwards from the north coast of Tunisia.

Given the conditions in which pressure jumps have been found to be most frequent we have an analogy with the work of Townsend (1964) who showed experimentally in the laboratory that convection in an unstable layer may produce internal waves within the interface between two fluids. He proceeded to suggest then that the energy of these waves would be dissipated in shallow patches of turbulence within the interface. A report of turbulence of this nature has previously been made by the present author (Perry, 1972). A similar conclusion was reached by Pothecary (1954) who showed anomalous fluctuations of wind to occur over a large area as wave oscillations induced by convectional downdraughts associated with an area of thunderstorms propagated away from the initial outflow of cold air.

In this investigation there is substantial evidence that most of the pressure jumps occurred at a time when the middle layers were overturning, causing an irregular barograph trace, and that the pressure jumps resulted from the large vertical accelerations in marked updraughts and downdraughts. Evidence was visible in the frequency of castellanus clouds and mamma observed at these times, and in the sudden onset of rain, albeit on some occasions only a few large drops, which accompanied most pressure jumps.

It may be postulated that when conditions are favourable for pressure jumps, the overturning motion will produce waves within the inversion at a lesser height which may degenerate into turbulence patches. Furthermore, given sufficient impetus, the wind regime above the inversion breaks through to the surface, producing a squall and a wind direction approaching that which prevails at about the 850-mb level. The change of mean wind direction measured

over three hours, preceding and following a pressure jump, showed a tendency for backing, and although surface temperatures did not show evidence of a fall of temperature, this backing of wind may be indicative of cooling in the inversion layer.

It also follows that in favourable conditions of lapse rate and wind shear, which are beyond the scope of this investigation, induced waves in the inversion will on occasions produce the oscillations in wind speed and direction noted on a few occasions here and previously reported by Kirk (1961 and 1963a–d) and Lamb (1954).

Finally, it is logical to assume that the conditions for pressure jumps at Luqa, Malta are not unique and that in similar synoptic types they might occur over large areas of the Mediterranean, while the intensity of the phenomena associated with the rapid changes of pressure would be enhanced if they occurred as a prelude to the passage of a surface or upper-air trough or frontal system.

Forecasting pressure jumps, anomalous surface winds and severe low-level turbulence

The analysis of pressure jumps has shown that for Luqa, Malta, the large majority occur as a result of special meteorological conditions. These are summarized in an Appendix which may be used as a forecasting guide to occasions when pressure jumps, anomalous surface winds and severe low-level turbulence might be expected to occur.

Earlier, in the discussion of the weather and cloud associated with pressure jumps, it was shown that although the barograph trace was irregular for long periods and conditions were favourable to pressure jumps, only a few significant jumps actually occurred. In investigating the conditions at the time of the jumps in excess of 4 mb it was also found that not all these pressure jumps were associated with anomalous surface winds; indeed, on several occasions little or no significant change in the surface wind occurred. It follows that although the majority of the pressure jumps at Luqa, Malta occurred within the conditions given in the Appendix, the converse is not true, and the Appendix should therefore be treated as a guide to periods when pressure jumps, anomalous surface winds or low-level turbulence might occur, and as a test of anomalous observations which might otherwise be discarded as erroneous.

Users of this advice, more especially pilots of light aircraft and captains of marine craft, while usually aware of the danger associated with the thundery squalls produced by cumulonimbus clouds in the Mediterranean are often surprised by the rapid changes which sometimes occur, either with little or no cloud or with apparently innocuous patches of unstable medium cloud, and it is considered that the Appendix, sensibly used, would be of value in these circumstances. Additionally, the Appendix may be of considerable value in regard to the use of altimeter settings in defining occasions when sudden changes of pressure can occur which present a hazard to navigation.

Conclusions

Pressure jumps are likely at Luqa, Malta and indeed also over other Mediterranean localities when there is a two-layer airflow with a potentially unstable layer in the middle atmosphere overlying a near-surface layer which has been cooled by advection over the sea. In such conditions the barogram becomes

irregular and anomalous changes of wind may accompany sharp changes of pressure which can exceed 4 mb in less than an hour and may do so in a few minutes.

These conditions are also conducive to the production of severe low-level turbulence and as such should be watched for the development of rotors or line-squalls. On many occasions they explain the oscillatory variations in wind, pressure and temperature and may account for the various reports of violent Mediterranean squalls which are difficult to explain within the context of the normal synoptic analysis. A forecast guide is given in the form of an Appendix which may be used to predict periods when such conditions might occur or to investigate their occurrence in retrospect.

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Appendix I—Forecasting Guide

This section summarizes in convenient form the synoptic developments which may result in the occurrence of pressure jumps, anomalous surface winds and severe low-level turbulence at Luqa, Malta. Situations which, in the light of experience, are considered to be favourable, occur when:

(a) stationary or slow-moving upper trough/ridge patterns over the central Mediterranean produce an area of low pressure over Tunisia and a ridge of high pressure to the east of Malta, or

(b) transient southerly or south-easterly airstreams develop ahead of desert lows or troughs moving either north-east from the west coast of Libya or south-east from the north coast of Tunisia, and

(c) as is often the case in these circumstances the surface winds over Malta become easterly and veer with height to become westerly by 700 mb (see

example in Figure 7), while the radiosonde ascent shows a potentially unstable layer in the middle troposphere separated from a cooler surface layer by an inversion or stable layer at about 900 mb (see example in Figure 5).

If either (a) or (b) results in (c) then

(1) the barogram changes in character and becomes irregular (see example in Figure 1) and severe low-level turbulence may occur within the inversion between the two air flows, i.e. between the cooler surface layer and the potentially unstable layer above.

(2.1) If unstable medium cloud is present (i.e. mamma or castellanus) a pressure jump is probable, often with onset of rain; otherwise

(2.2) if the ascent is dry (i.e. only a trace of Ac) then a pressure jump is still possible but less likely;

(3) after the first pressure jump others may follow, either positive or negative, and may on rare occasions exceed 4 mb (see example in Figure 4);

(4) anomalous surface winds may occur which could satisfy squall criteria, or because of the rapid change in direction (possibly 180°) may be in effect equivalent to a squall (see example in Figure 3); and

(5) a squall line or rotor cloud can occur especially if an upper trough or surface discontinuity is approaching, and may be associated with severe low-level turbulence.

551.525.2

EXTREME VALUES OF GRASS-MINIMUM DEPRESSIONS AT WEST RAYNHAM

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Summary

Grass-minimum temperatures were examined to establish the annual frequency and seasonal variations of extreme values of their depression below screen minima.

1. Introduction

Davies (1975) has recently suggested that grass-minimum depressions are greater in south-west England than in eastern England, and also that nights with large grass-minimum depressions may be most frequent in spring.

A check of the depressions at West Raynham, using the data extracted for an earlier paper by Pickup (1976) revealed that there is little difference between the two locations as regards the magnitude of the largest depressions, and that the frequency of such depressions during the year shows a more random variation at West Raynham than at Westbury-on-Trym.

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* The author is now at Manchester Weather Centre.

2. Data

The West Raynham observations for the period from 1 January 1961 to 19 March 1970 had previously been analysed—a total of 3240 nights. The nights since the reopening of the office in 1972 were added to include the period from 26 January 1972 to 31 March 1975—809 nights, making a grand total of 4049 nights.

From August 1969 to March 1970, and again from January 1972 to March 1975 there were no weekend observations.

In order to obtain a direct comparison with the figures for Westbury-on-Trym a separate analysis for the period from 26 January 1972 to 31 December 1973 was also completed.

3. Results

The results of the analysis for the period from January 1972 to December 1973, which includes mean values of the depression Δ of the grass-minimum temperature below the screen-minimum temperature, and the percentage frequency for each month of observations for which this depression reached or exceeded 6·5 deg are shown in Table I.

The number of nights with $\Delta \geqslant 6{\cdot}5$ deg, and the maximum value of Δ for each month, for the period from January 1961 to March 1975, are shown in Table II.

4. Discussion

A direct comparison between the West Raynham and the Westbury-on-Trym results for 1972–73 shows little similarity. The mean values of Δ for each month at West Raynham were almost half those at Westbury-on-Trym.

The maximum monthly values of Δ are in closer accord but would seem to tend to support Davies's view that grass-minimum depressions in south-western England are greater than those found in eastern England. The maximum depression at West Raynham was greater than that at Westbury-on-Trym in only two months—May and September.

As these large values of Δ are infrequent at West Raynham—1 night in 108 for the period from January 1961 to March 1970; 1 night in 37 for the period from January 1972 to March 1975; 1 night in 78 overall—it would seem logical to consider as long a period as practicable in order to get a true picture of the annual and monthly frequency.

The results in Table II show that in all months during the period from January 1961 to March 1975 there was at least one night with a depression of 6·6 deg, and seven of the months had depressions greater than those recorded at Westbury-on-Trym during the period from January 1972 to December 1973. Of the 52 occasions at West Raynham, 30 occurred in the period from January 1961 to March 1970 and 22 between January 1972 and March 1975. The years with the greatest and least number of occasions of $\Delta \geqslant 6{\cdot}5$ deg were 1973 with 9, and 1965 and 1968 with only 1 each.

Davies has suggested that there might be a maximum frequency in spring. The West Raynham results show a far more variable spread throughout the year, with maxima in February, May and September with 8 each, and minima in January and November with 1 each. It is interesting to note that all the

TABLE I—GRASS-MINIMUM DEPRESSION (Δ) AT WEST RAYNHAM FOR THE PERIOD FROM JANUARY 1972 TO DECEMBER 1973

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean (deg)	1·66	1·98	2·89	2·71	2·73	2·63	2·10	2·53	2·70	2·33	2·15	1·79	2·38*
Highest (deg)	5·4	8·0	6·1	7·1	8·2	6·9	6·5	6·2	7·7	6·7	6·6	5·4	8·2†
No. of obs.	26	41	49	36	43	43	45	41	46	46	46	35	497‡
No. of obs. ⩾ 6·5 deg	0	3	0	1	2	1	1	0	2	1	1	0	12‡
Percentage of obs. ⩾ 6·5 deg	0	7	0	3	5	2	2	0	4	2	2	0	2*

* Mean † Extreme ‡ Total

TABLE II—GRASS-MINIMUM DEPRESSION (Δ) AT WEST RAYNHAM FOR THE PERIOD FROM JANUARY 1961 TO MARCH 1975

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
No. of obs. ⩾ 6·5 deg	1	8	4	2	8	6	5	3	8	3	1	3	52‡
Highest (deg)	6·8	8·9	7·6	7·1	8·2	8·0	7·0	7·1	7·7	7·4	6·6	8·6	8·9†

† Extreme ‡ Total

8 occasions in February have occurred since the office reopened in 1972, which supports the suggestion that it is desirable to consider long periods when investigating variation in the incidence of large values of Δ.

The grass-minimum temperatures at Westbury-on-Trym are read every 24 hours and refer to the preceding 24, whereas the West Raynham minimum values refer to the period from 21 GMT to 09 GMT. Although the different periods and sites may account for part of the difference between the two areas, there is still a large variation in the percentage frequency of nights with $\Delta \geqslant 6 \cdot 5$ deg, namely 11 per cent at Westbury-on-Trym and only 1 or 2 per cent at West Raynham. It will be interesting to see the change in frequency at Westbury-on-Trym if longer periods can be investigated.

It has already been suggested by Pickup (1976) that maximum values of Δ occur when the air is dry initially and when, subsequently, little dew or frost forms. During this investigation it was noted that many of the occasions with $\Delta \geqslant 6 \cdot 5$ deg occurred during, or following, a dry spell.

5. Conclusion

Suitable conditions such as clear skies and light winds being given, values of the grass-minimum depression greater than 6·5 deg are likely at West Raynham at any time of year; this result had previously been discovered for Westbury on-Trym, and is now presumed to hold in other areas as well.

The possibility of large grass-minimum depressions may increase during spells of dry weather. An investigation to find a possible correlation between rainfall anomaly and Δ is now being undertaken.

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551.593.653

NOCTILUCENT CLOUDS OVER WESTERN EUROPE AND THE ATLANTIC DURING 1975

By D. H. McINTOSH and MARY HALLISSEY
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Table I summarizes the observations of noctilucent cloud made over western Europe and the Atlantic during 1975. These reports were provided by the network of observers, professional and amateur, associated with the Aurora Survey centred at the Balfour Stewart Auroral Laboratory of the University of Edinburgh.

The dates in Table I cover the period of optimum viewing of the clouds between geographic latitudes 50° and 60°N. The periods of time during which the clouds were observed appear in the second column. These should not be taken as being necessarily the total duration of the display; this is stated where possible, but it is obviously difficult, particularly for voluntary observers, to record a display to the point of disappearance. Brief notes on the displays appear in the third column. In the remaining columns, details of the relevant station co-ordinates are listed to the nearest half degree, and the maximum elevation and limiting azimuths of the observed cloud, where known.

TABLE I—DISPLAYS OF NOCTILUCENT CLOUDS OVER WESTERN EUROPE AND THE ATLANTIC DURING 1975

Date—night of	Times UT	Notes	Station* position	Time UT	Max. elev. (degrees)	Limiting azimuths (degrees)
6/7 May	2200	Small patch of NLC, 30° elevation in NW.	57°N 02°W	2200	30	345
20/21	2050	Patch of bright NLC, possibly whirls, high to NW against veil background.	51°N 01°E	2050	30	345
30/31	2320–2400	Faint NLC seen above clearly visible north horizon. Observations discontinued 2400.	56°N 04·5°W	2320	4	340–355
7/8 June	2130–0045	NLC—no details.	55°N 04·5°W			
	0400	NLC disappearing to NE.	52·5°N 07·5°W	2345	6	
				0045	3	
9/10	2225–0020	Weak display seen in otherwise clear	56°N 04·5°W	2335	40	295
		sky; banded structure drifted slowly		0010	20	350
		west and south.	55°N 04·5°W			
10/11	2132	Veil and banded patch of NLC visible in otherwise clear sky.	51°N 01°E	2132	15	335
12/13	2305–0215+	From Milngavie (56°N) NLC became	56°N 04·5°W	2330	13	290–010
		visible at 2302 in NW.		0035	10	
		Between 2400 and 0030 there was	55°N 04·5°W			
		some drift to west and the bands	54°N 09°W	2400	6	330–008
		had bright green iridescent sheen.	53·5°N 09°W	2338	7	310–025
		Display seen as bright from Ireland;		0130	11	345–015
		from Scotland though not bright		0215	14	325–005
		'rather exquisite in texture and colour'—brightest 0035 when numerous whirls appeared to north. Photographed Kiltimagh, western Ireland, 0200.	52°N 10·5°W			
14/15	2250–0137	Clear skies noted 2230 Dundee	57°N 02°W	0030	90	270–080
		(56·5°N), medium bright NLC in	56·5°N 03°W	2250	12	
		broad bands visible at 2250 obscured by tropospheric cloud after 2330. At 0030 NLC was seen from Aberdeen as extensive display of diffuse structure over entire northern sky. Isolated patches and bands photographed Edinburgh 0119 and 0129.	56°N 03°W			
15/16 June	0200–0210	Possible sighting of NLC high NW just before spread of dawn light.	52°N 02·5°W	0200	58	345
16/17	2210–0235	Small patches of NLC seen in north	56·5°N 07°W	2400	27	340–045
		—at times between tropospheric		0100	25	045
		clouds.	55°N 04·5°W	2300		355
			53°N 08°W	0145	10	350–040
				0220	15	
17/18	2140–2315	Possible NLC showing through gaps in tropospheric cloud.	55°N 04·5°W	2230		355
18/19	2117	Bright banded patches of NLC seen against veil background.	51°N 01°E	2117	5	330–025
19/20	0050–0125	Characteristic silvery streaks of the NLC showing brighter than high tropospheric clouds.	57·5°N 03·5°W	0100	21	040–060
20/21	2210	Possible NLC to north.	55°N 04·5°W			
21/22	0300	'Glow' reported from Ocean Weather Ship *Weather Reporter* thought to be NLC.	53°N 20°W			
25/26	2325–2400	Faint wisp of NLC suspected at 2325; very faint and with little structure at 2345. Photographed at 2332.	57°N 02°W	2400	8	020
26/27	0100–0200	Small patches of NLC low in NNE,	56·5°N 07°W	0100	3	020
		moving slightly south and west before fading into light sky.		0200	9	360–045

* To nearest 0·5 degree.

TABLE I—*continued*

Date—night of	Times UT	Notes	Station position	Time UT	Max. elev. (degrees)	Limiting azimuths (degrees)
27/28 June	2100–2200	Typical banded structure seen through binoculars. Westerly movement noticed 2115 with brightening in NW—this formation faded 2135 but new formations in NE to 12° elevation. These last observed very faint in NNE.	55°N 14·5°E	2100	20	345–045
				2115	25	
				2135	12	045
				2150	12	360–045
28/29	2230–0235	This widely observed display reported from Denmark to be exceptionally brilliant (2230). At Lerwick three main bands lay N–S across zenith. Bands, billows and transverse ripples seen from northern stations to high elevation. Little movement seen from more southern stations.	60°N 01°W	0010	90+	
				0030	90	
			57·5°N 03·5°W	2345	23	330–050
				0040	20	340–010
			57°N 02°W	2340	20	
				2400	45	
			56°N 03°W			
			55·5°N 01·5°W	0050	10	360–045
			55°N 14·5°E	2230	12	340–020
				2345	20	340–020
			54·5°N 06°W	0100	50	340–075
			54°N 02·5°W	0105	15	
			54°N 04·5°W	2350	8	010–035
				0030	8	015–025
			54°N 09°W	0155	10	
			53·5°N 03°W	2345	4	355–020
				0100	4	360–045
				0130	4	360–010
			53°N 02·5°W			
2/3 July	0050–0130	Rather faint 'streak' of NLC 10° elevation and parallel to N horizon; small patch of billows in NNE.	60°N 01°W	0050	10	360–045
3/4	2250–0145	Faint NLC first seen in NE; elevation increasing until still visible NW–ESE through encroaching tropospheric cloud.	60°N 01°W	2250	20	050
				2315	30	050
				2350	50	080
				0050	65	120
				0135	10	330
4/5	2250–0250	First reported from Aberdeen (57°N) and by 2310 seen also to high elevation in southern Norway, Tiree and Skye. NLC built up to extensive display of parallel bands, close-packed herring-bone pattern wave structure, with typical drift movements to W and S. NLC seen from Lerwick covered much of sky. (Display photographed 0008–0128 in Edinburgh.)	60°N 01°W	2355	90+	
				0055	90+	
			59°N 09°E	2315	58	
			58°N 05·5°W	2400	80	
			57·5°N 03·5°W	2350	20	045
			57·5°N 06°W	2305	20	330–050
				2330	35	330–060
				0135	25	360–085
			57·5°N 07·5°W	2330	29	320–050
				2400	30	320–065
				0030	28	320–060
				0120	33	330–070
				0150	47	330–070
			57°N 02°W	2310	22	340–020
			56·5°N 03°W	0100	20	360
				0200	20	
			56·5°N 07°W	2330	18	340–035
				0245	15	050
			56°N 03°W	0050	20	
			55°N 04·5°W			
6/7	0005–0110	NLC in NNE partly obscured by tropospheric cloud. The lower edge of banded patches tinged with red on E.	57·5°N 03·5°W	0100	15	360–030
7/8	2310–0015	Moderate intensity NLC seen as sky darkened; bands with herring-bone structure and small diffuse patches.	58°N 06·5°W	2310	11	345–030
8/9	2330–0130	Faint NLC display seen in otherwise almost clear sky; bands, patches, wisps and wave structure identified.	58°N 06·5°W	2330	9	025–045
				0020	6	010–055
				0130	6	
			57·5°N 07·5°W	0025	5	040–045
13/14	0150	Weak NLC veil in NNW viewed during period clear of tropospheric clouds.	53°N 0·5°E	0150	8	340–360
14/15	2135	Complicated structure of bright NLC bands and billows against veil background.	51°N 01°E	2135	55	
17/18	2130–0150	Low-brightness banded areas of NLC seen in Denmark, which increased in brightness to beautiful blue/green display with usual westward movement. Seen in western Scotland as small patches of NLC NW–NNE and large patch to NE. Colour prints from Håstrup.	56·5°N 07°W	2350	9	315–020
				0050	10	045
			55·5°N 10·5°E	2130	10	340–020
				2240	12	
17/18	0325–0415	Pilot of eastward bound transatlantic aircraft reported flying under bright banded display of NLC.	55°N 40°W	0325		045–090
			55°N 30°W	0407	60	360–090
			56°N 28°W	0415	90+	

TABLE I—*continued*

Date—night of	Times UT	Notes	Station position	Time UT	Max. elev. (degrees)	Limiting azimuths (degrees)
18/19 July	2350	NLC visible NNW–N'E through gaps in tropospheric cloud.	56·5°N 07°W	2350	12	345–010
20/21	0050–0250	Patches of NLC of varying brightness NW and NE–ENE. Banded structure discernible from Kirkwall. Single streak still visible in NW from Aberdeen at 0240.	59°N 03°W	0100 0200	10 15	030–050 030–050
			57·5°N 03·5°W	0050 0150	8 10	045–080 045
			57°N 02°W	0200	25	345–360 and 050–070
			56·5°N 03°W	0145	7	027–034
21/22	2105–2215	Faint NLC bands seen from Alrø above heavy tropospheric clouds in NNW, developing to brighter and extensive formations (mainly bands) WNW–NE. Covered by cumulus clouds at 2215. (Photographed 2137–2205.)	56°N 10°E	2105 2137	15 18	345 290–045
25/26	2035–2100 2210–2315	Banded formation seen from Denmark to form in NNW, fading 2100. Seen again faintly 2210; increased activity and bright formation 2300.	57°N 9·5°E	2250	7	320–360
			56°N 10°E	2035 2045 2210	8 10 12	345–360
30/31	0100–0300	Horizontal bands and patches seen low NE from Aberdeen and Kirkwall. Long-focus photographs were taken in Aberdeen when cloud was low but structurally clear in NE, 0154–0227.	59°N 03°W 57°N 02°W	0100	5	010–060 045
31 July/ 1 Aug.	2055–2300	Low elevation E–W bands of NLC seen in Denmark; varying brightness. At 2140 rapid changes of form and brightness then fading by 2215, at which time new formations appearing. (Photographs 2120, 2123.)	56°N 10°E	2105 2215	7 4	345–360 360
2/3 Aug.	2145–2200	Extensive faint wave structure NLC above low tropospheric clouds.	59°N 09°E	2145	80	360
3/4	2145–2200	NLC veil to high elevation.	59°N 09°E	2145	80	360
4/5	0100–0200	Thin bands of NLC E–W seen overhead, receding to 40° elevation at 0200.	59°N 03°W	0100 0200	90 40	 360–045
6/7	2200–2400	Possible NLC low N.	58°N 06·5°W 56·5°N 07°W			

TABLE II—ADDITIONAL REPORT OF NOCTILUCENT CLOUDS OVER WESTERN EUROPE DURING 1974

Date—night of	Times UT	Notes	Station position	Time UT	Max. elev. (degrees)	Limiting azimuths (degrees)
20/21 June	2300–0045	Suspected display increased to become bright band and whirls at 2330 and intensely bright band at 2340, and fading to barely visible veil which extended to high elevation at 0030. Series of colour and black-and-white photographs 2330–0018.	55·5°N 04·5°W	2330 0015	13 20	315–335 310–360

The 38 noctilucent-cloud appearances listed for 1975 include a larger than usual number of 'single-station' reports. All were from experienced observers, some accompanied by photographs, and all have been included in the list. During the year the longest unbroken series of displays was recorded in mid June; in 1974 this occurred in July.* Since northern stations were then

*MCINTOSH, D. H. and HALLISSEY, MARY 1975 Noctilucent clouds over western Europe and the Atlantic during 1974. *Met Mag*, 104, pp. 180–184.

experiencing almost continuous daylight the reports were received from central Scotland and further south—the exception being Aberdeen (57°N) on 14–15 June when diffuse forms were seen to cover the entire northern sky around 0030 h. During the period, only the displays on 12/13 and 14/15 June were seen to spread to any great extent.

Two widely reported displays on 28/29 June and 4/5 July were notable because they were bright enough to be seen from Lerwick during the short period of twilight there. On each occasion, too, the cloud field was extensive, visible in Norway and Denmark as well as over the length and breadth of the United Kingdom and Ireland, and showed the full panoply of bands, ripples, billows and veil. Photographs of these displays are available.

Appearances of the clouds from 6 to 9 July were seen only from the west of Scotland. They were not bright, but structure was discernible.

On 17/18 July NLC was seen from latitudes 55–56·5°N from Denmark, western Scotland and mid Atlantic. The observer from this last position was interested to know why he should be flying under this bright-banded cloud just one year since last seeing a similar phenomenon. The cloud observed from Denmark on this night was not seen above 12° elevation, but colour prints clearly show the cloud structure.

Three further displays between 21 July and 1 August were seen from Denmark and one from northern Scotland. The NLC by this time was appearing well to the north. Assuming a height of the cloud field of around 80 km, an observer in Denmark ventured an estimate that the cloud would be, at nearest, 500 km distant. This makes reasonable the inclusion in the list of three reports of the cloud for the nights 2–4 August. The reports, made from observing points at latitude 59°N—one station in Scotland and one in Norway—relate to cloud at high elevation, and were at first regarded as 'doubtful' observations.

One further possible display occurred on 6/7 August. The 'glow' reported from stations in west and north-west Scotland to be low in the north is thought likely to have been a sighting of NLC, aurora having been ruled out as a possibility.

Tropospheric clouds were as great a factor of obstruction to observation as in previous years, and there was at times the additional hazard of some fog and haze. There were, fortunately, few nights when completely cloudy conditions prevailed in all areas, and we pay tribute again to observers who are able to identify NLC through relatively small gaps in lower clouds.

We gratefully acknowledge the help of the many observers who have contributed the reports, sketches and photographs used in the compilation of this summary, and also the receipt of a Meteorological Office grant which enables the work to be carried out. Although the collection and publication of reports of visual aurora by this Department of Edinburgh University ended in 1975 we hope to be able to continue to receive and publish NLC reports for some further years.

NOTES AND NEWS

Retirement of Mr R. A. Buchanan

Mr Robert Andrew Buchanan, who retired on 31 May 1976, joined the Office in September 1939 after spending four years at Glasgow University, where he obtained an honours degree in Mathematics and Natural Philosophy. He

was also active in the University's Officers' Training Corps. After initial training he served during the earlier war years at Abbotsinch and H.Q. 18 Group RAF (Pitreavie), and in the autumn of 1942 was posted to Sullom Voe. He received a commission as a Flight Lieutenant in the Royal Air Force Volunteer Reserve in April 1943, and in June of that year was gazetted as Squadron Leader and posted to the Azores. He served in that area for the next two years and on his return to the United Kingdom went to H.Q. 13 Group (Inverness) from August 1945 until early 1946 when he was demobilized from the RAFVR. He then went to Washington, D.C., for an important and taxing job in liaison and co-ordinating work for meteorological services for the Allied Forces—a job which, although difficult, was very much to his liking. On return to the United Kingdom in 1947 he went to Dunstable, where he did a long stint on the Central Forecasting Office Upper Air Roster until September 1953 when he was promoted to Principal Scientific Officer. He was then posted to Northern Ireland as Senior Meteorological Officer at Aldergrove, where he stayed until September 1959. He then joined MetO 17 (Defence and International) at Victory House, Kingsway, London WC2, and once more became involved in international work, which he enjoyed immensely and carried out very effectively. He moved with the branch to Bracknell in July 1961. He was transferred for a short time in 1966 into MetO 6 (Defence Services) before joining MetO 7 (Public Services) in February 1967; here he was primarily engaged in work connected with the need for, and application of, meteorological services in industry and commerce. His previous experience gained in the international sphere in liaison work and the ability to make personal contacts stood him in good stead for his work in MetO 7. Although the bulk of that work was directed towards national interests he also retained some interests and responsibilities in the international field by serving on the World Meteorological Organization Executive Committee Panel on Development and Application of Meteorology to Economic and Social Problems. He also contributed to the planning and international work in the early 1970s which led to the European Centre for Medium-range Weather Forecasts which was established at Bracknell in 1975.

In 1973 he was promoted to Senior Principal Scientific Officer and posted to H.Q. Strike Command at High Wycombe as Chief Meteorological Officer. From personal acquaintance and friendship over many years I know that Mr Buchanan has had an interesting career and that his work and achievements, especially in the international field, have given him much personal satisfaction and a deservedly wide circle of friends.

Many of his contemporaries also know his wife Mary, either through her work in the Office in the 1940s when she was for a while Personal Secretary to the late Mr E. Gold, or later because she often accompanied her husband on his international visits. Their numerous friends will wish Robert and Mary a long and happy retirement and hope they enjoy good health to enable them to follow their many interesting activities for many years.

N. BRADBURY

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